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(54) **Masted lift truck control systems**

(57) A computer controls the height of the lift and tilt of the mast. The program adjusts the height and tilt on data recovered from a store.

A controller 100 receives information from a lift height sensor 57 and tilt limit switches 82, 83. These read respectively from the height of a lift (having a cylinder 6 and a fork 8) and the inclination of a tilt cylinder 5. The controller 100 controls lift and tilt actuators 90, 93 which respectively operate hydraulic valves 91, 94 driven from a pump 92.

FIG. 1

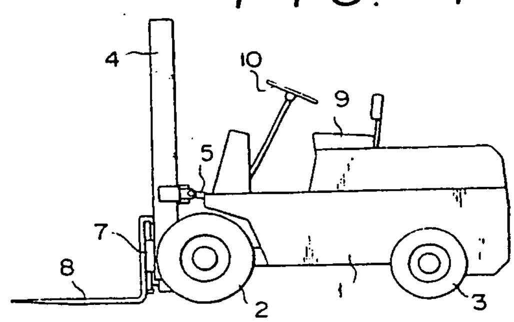

FIG. 2

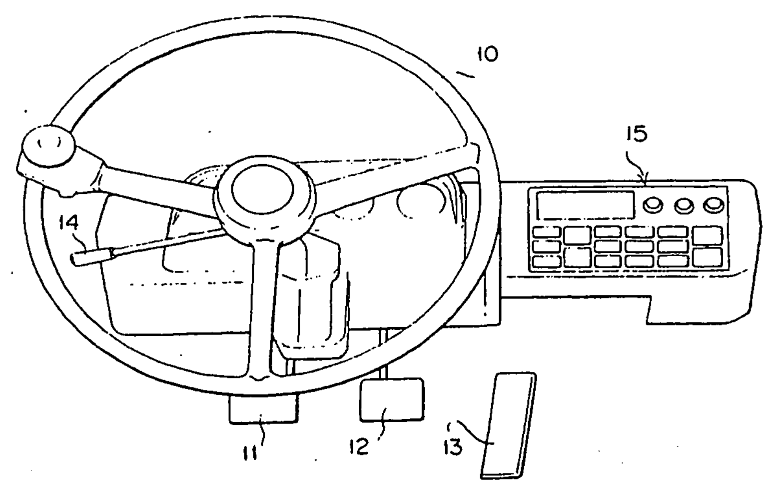

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FIG. 1

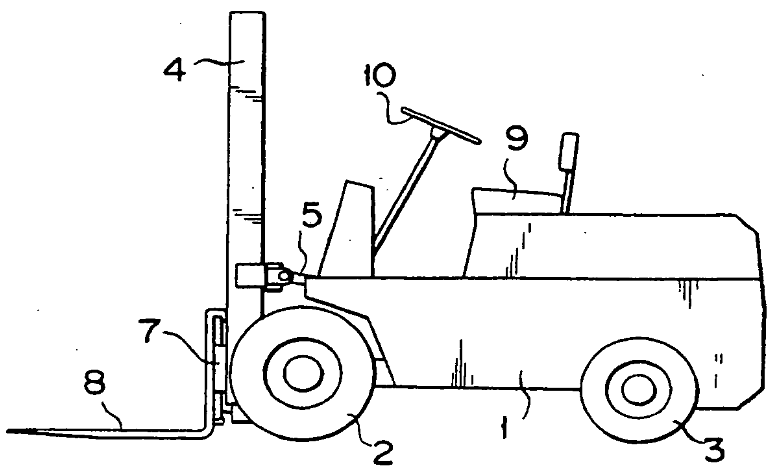


FIG. 2

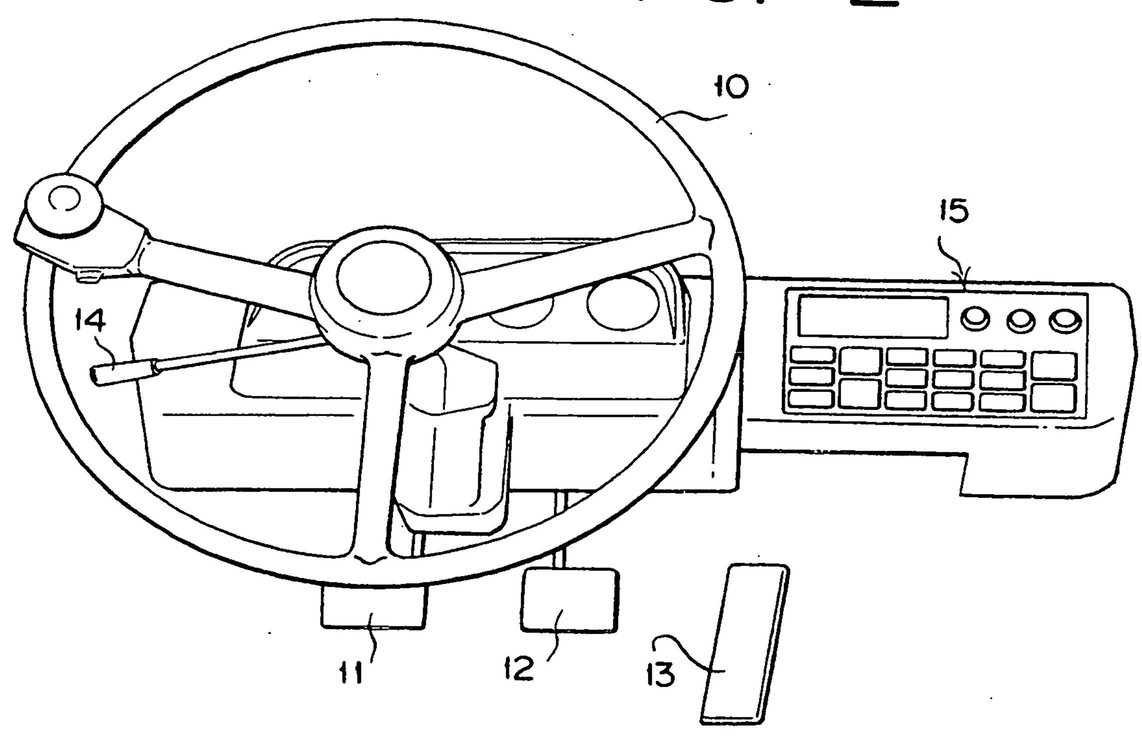


FIG. 3

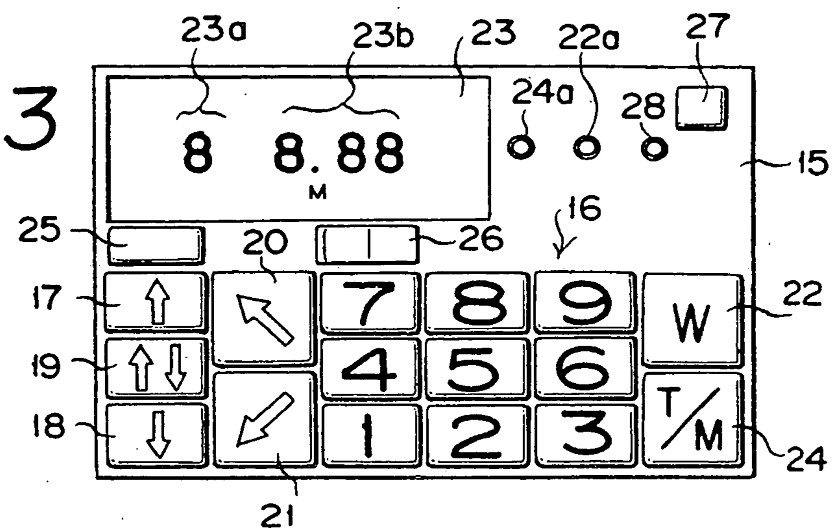
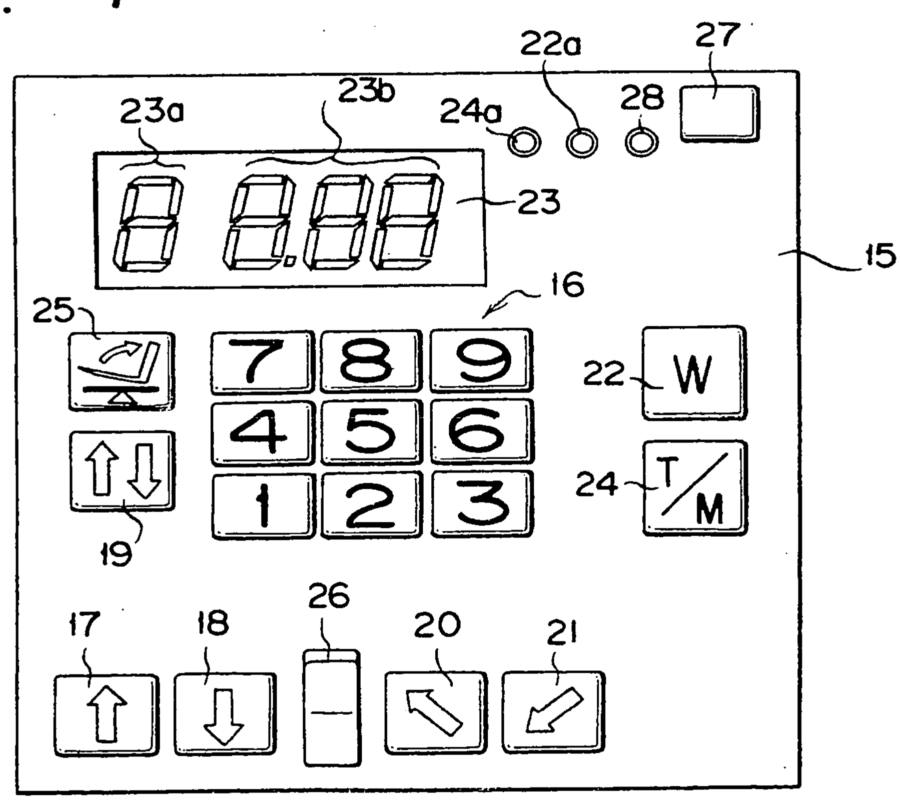

23a
23b
23
22a
27
24a
28
8 8.88
M
15
25
20
26
16
17
7
8
9
W
22
19
4
5
6
18
1
2
3
T/M
24
21

FIG. 4


22a
27
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W
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24
T/M
1
2
3
19
26
17
18
20
21

FIG. 5

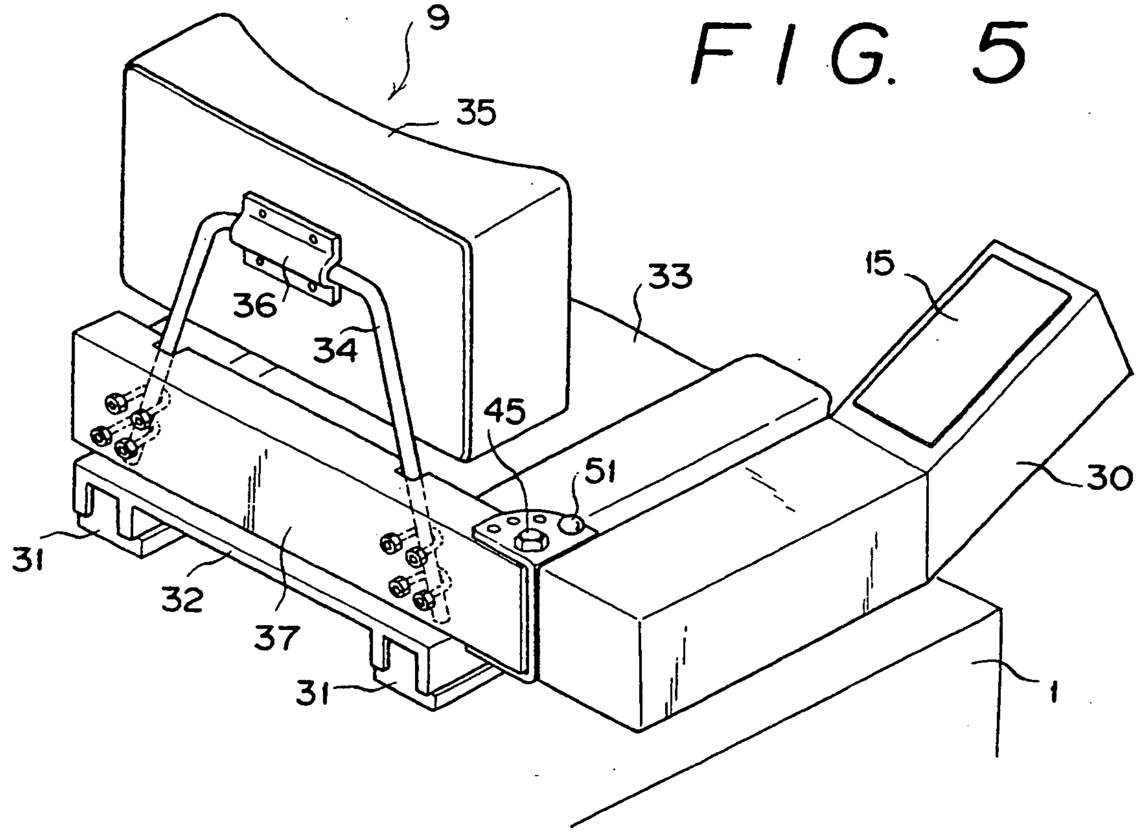

9
35
36
34
33
15
45
51
30
31
32
37
31
1

FIG. 6

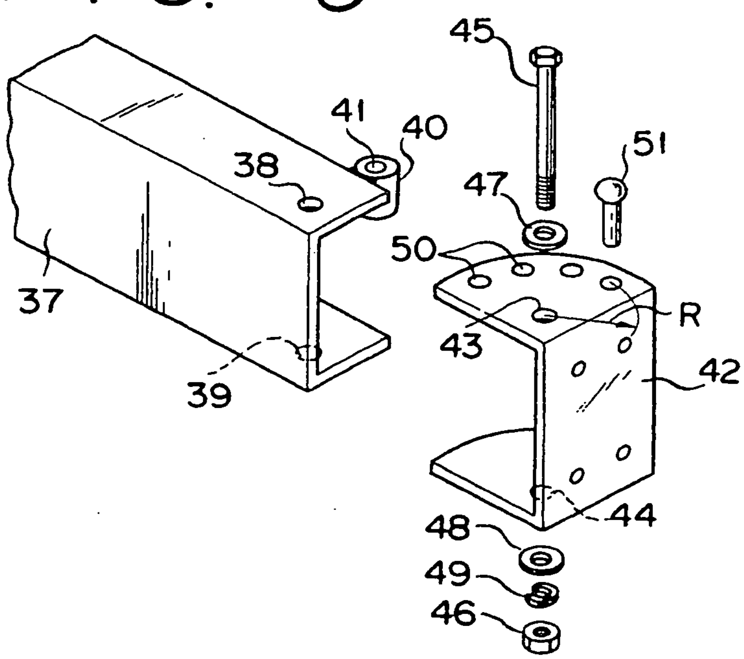

45
41
40
38
51
47
50
R
43
37
42
39
44
48
49
46

FIG. 7

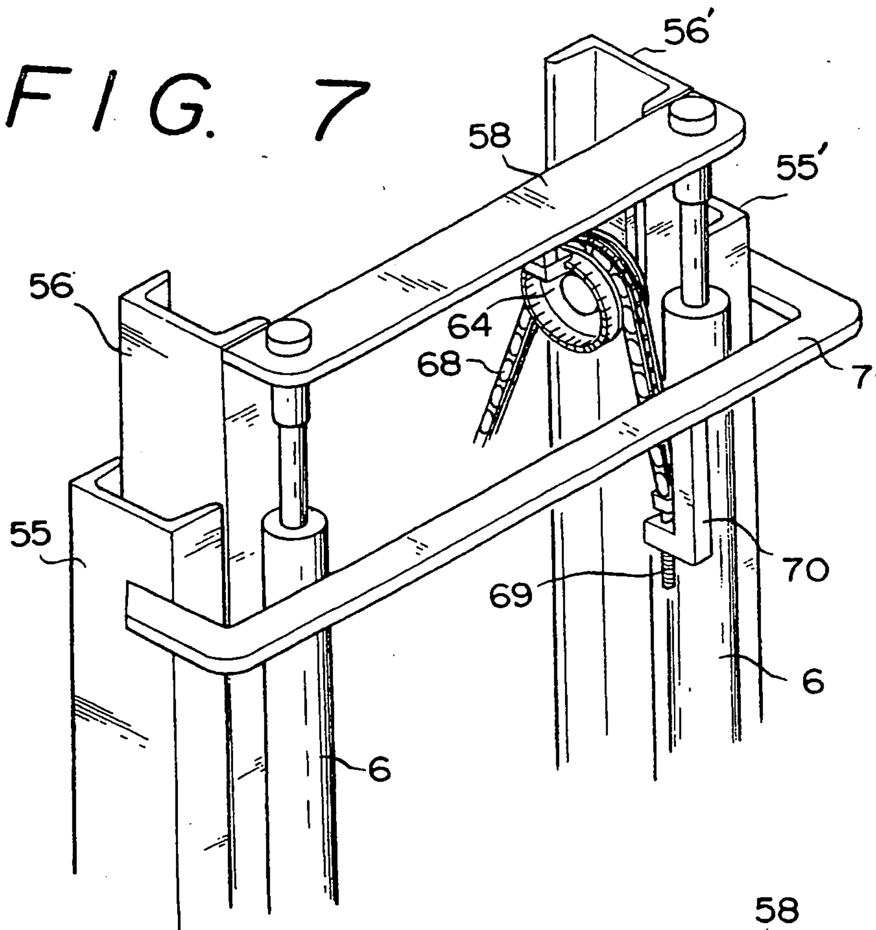


FIG. 8

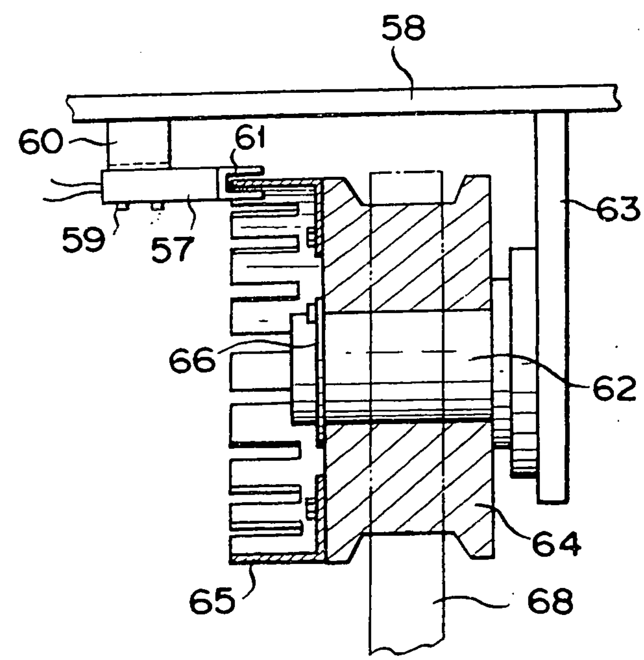


FIG. 9

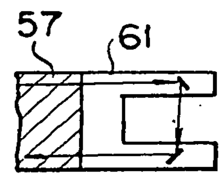


FIG. 10

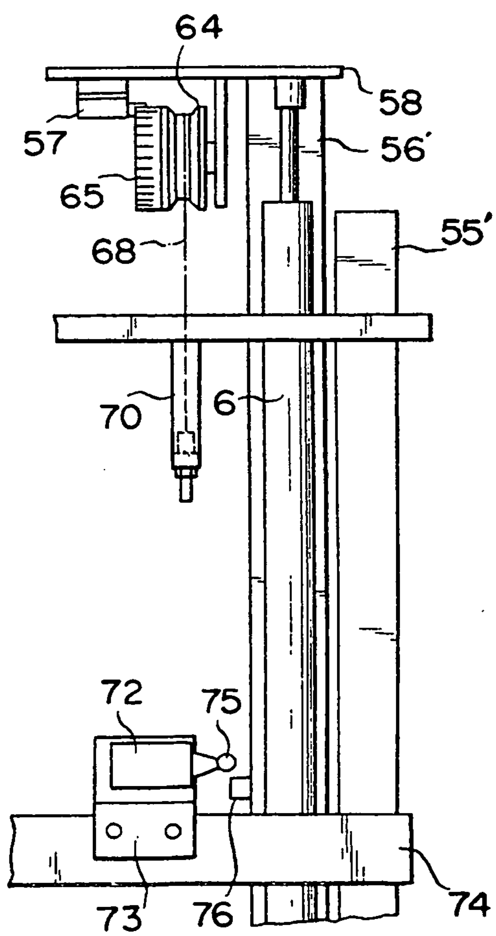


FIG. 11

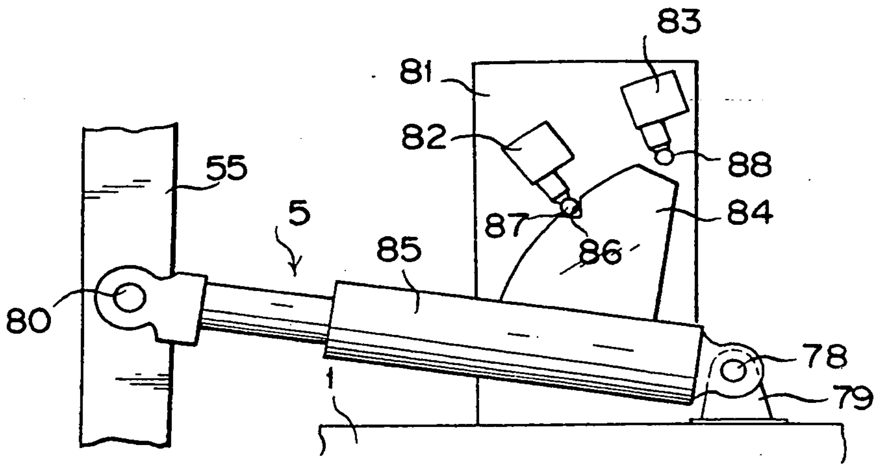
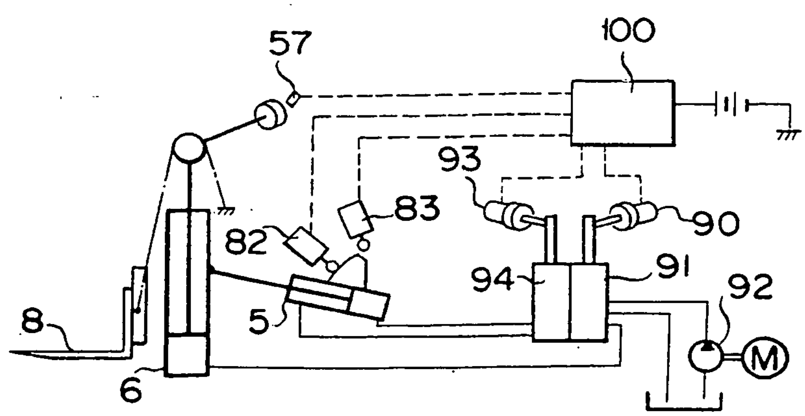


FIG. 12



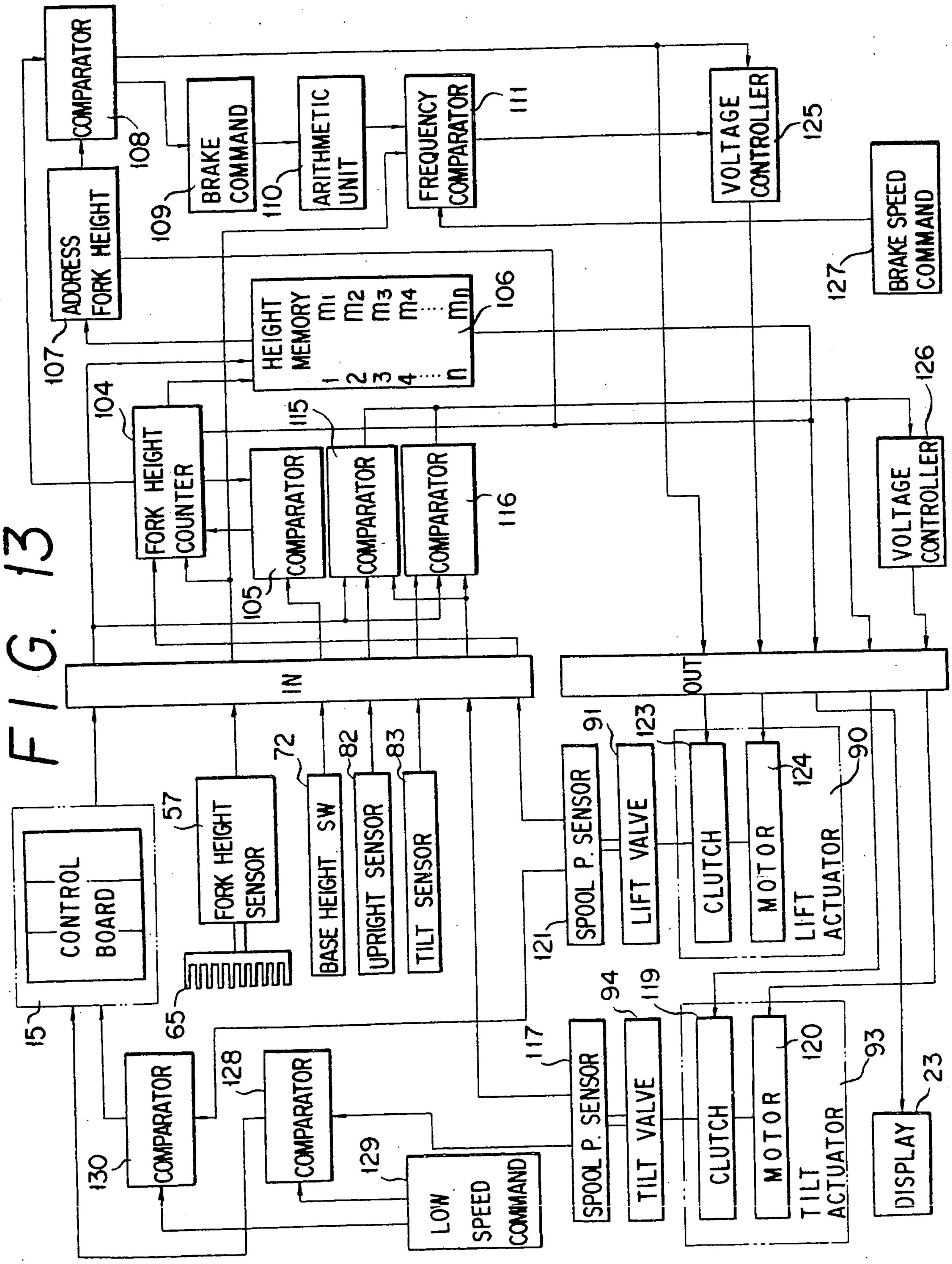

COMPARATOR
108
ADDRESS FORK HEIGHT
107
BRAKE COMMAND
109
ARITHMETIC UNIT
110
FREQUENCY COMPARATOR
111
VOLTAGE CONTROLLER
125
BRAKE SPEED COMMAND
127
HEIGHT MEMORY
1 2 3 4 ... n
m1 m2 m3 m4 ... mn
106
FORK HEIGHT COUNTER
104
COMPARATOR
105
COMPARATOR
115
COMPARATOR
116
VOLTAGE CONTROLLER
126
IN
OUT
CONTROL BOARD
15
FORK HEIGHT SENSOR
57
65
BASE HEIGHT SW
72
UPRIGHT SENSOR
82
TILT SENSOR
83
SPOOL P. SENSOR
121
LIFT VALVE
91
CLUTCH
123
MOTOR
124
LIFT ACTUATOR
90
SPOOL P. SENSOR
117
TILT VALVE
94
CLUTCH
119
MOTOR
120
TILT ACTUATOR
93
DISPLAY
23
COMPARATOR
130
COMPARATOR
128
LOW SPEED COMMAND
129

FIG. 13

SPECIFICATION

Masted lift truck control systems

The invention relates to control system for masted lift trucks whereby the height of the lift and amount of the tilt can be automatically controlled. By setting these parameters, operator fatigue can be reduced or its effects overcome.

A system according to the invention comprises a computer for controlling mechanism for establishing the height of the lift and the tilt of the mast, the computer having a program for adjusting the said height and tilt operable on data recovered from a store.

Preferred features include a height detector, a base height indicator and a comparator therefor, a voltage controller for reducing the speed of movement as a desired height or tilt is approached, a height display, a control board having various push button switches for adjusting the height and tilt. The control board may be mounted on a driver's seat or on a dash board.

The height detector may comprise a circular slit plate rotatable with the up and down movement of the lift adapted to interrupt the passage of light to a photo-sensitive switch. The tilt sensor may comprise a cam plate mounted on a tilt cylinder and adapted to operate limit switches. Means for high and low speed range operation, and for automatically bringing the mast to normal running height and tilt may be included.

DRAWINGS

Fig. 1 is a side elevation of a masted lift truck having a control system according to the invention;

Fig. 2 shows the controls of the truck of Fig. 1;

Fig. 3 is a plan of a control board in Fig. 2;

Fig. 4 is a plan of an alternative control board;

Fig. 5 is a perspective view showing how a control board may be mounted on a driver's seat;

Fig. 6 is an enlarged exploded view showing mounting details of Fig. 5;

Fig. 7 is a perspective view showing an upper part of the mast in Fig. 1;

Fig. 8 is an enlarged front elevation showing mounting of the fork-height sensor in Fig. 7;

Fig. 9 is an enlarged view showing a beam emitting portion of the fork-height sensor;

Fig. 10 is a front elevation of the mast in Fig. 1 showing how a base height switch is mounted thereon;

Fig. 11 is a side elevation showing how tilt sensor limit switches are mounted with respect to the tilt cylinder in Fig. 1;

Fig. 12 shows diagrammatically how lift and tilt cylinders in Fig. 1 are controlled according to the invention; and

Fig. 13 is a block diagram of the control system and associated actuators according to the invention.

Referring first to Fig. 1, reference numeral 1 denotes a body of a fork-lift truck mounted on front and rear wheels 2 and 3. Mounted on a front part of the body 1 is a mast 4 which is pivoted forwardly or backwardly by the action of a tilt cylinder 5.

Provided in front of the mast 4 and moved up and down by the action of a lift cylinder 6 through a drive chain (not shown) is a finger board 7 to which a fork 8 is mounted.

A driver's seat 9 is mounted on the body 1 and a steering wheel 10 is arranged in front of the driver's seat 9.

Arranged underneath the steering wheel 10 are a clutch pedal 11, a brake pedal 12 and an accelerator pedal 13. A shift lever 14 is also provided for changing the gear ratio of a transmission and forward and reverse changeover of the truck. Reference numeral 15 denotes a control board in which an electronic controller for controlling the movements of the mast 4 and fork 8 is housed. The control board 15 has formed thereon a plurality of push button switches and a display panel as shown in Fig. 3. The control board of Fig. 3 includes a push button address switch group 16, comprising a plurality of push button switches numbered from 1 to 9, for setting the height of the fork 8, push button switches 17 and 18 for raising or lowering the fork 8, a push button switch 19 for automatically raising or lowering the fork 8 to a preset and memorized height, push button switches 20 and 21 for tilting the mast 4 forwardly or backwardly, a push button switch 22 for storing the preselected height of the fork 8 in a memory circuit of the electronic controller which will be explained later, and a display panel 23 which is divided into two sections 23a and 23b.

The section 23a displays the selected push button number among the push button switch group 16 and the section 23b displays the height of the fork 8 in meter. The control board 15 further includes a push button switch 24 for changing the data displayed in the display panel 23, a push button switch 25 for commanding the fork-lift truck to take normal running posture, a push button switch 26 for high and low speeds changeover, an emergency stop button switch 27 for stopping the prime mover of the truck in case of emergency, indicator lamps 22a and 24a for indicating the switches 22 and 24 being pushed on, respectively, and an indicator lamp 28 for monitoring the battery for the electronic controller. All of these switches, display panel and indicators are connected to the electronic controller which will be later explained in detail.

Fig. 3 shows one example of the layout or arrangement of the various switches and of course it is possible to provide many modifications thereof, one of which is shown in Fig. 4.

Although the control board 15 can be arranged in the dash-board of the truck as shown in Fig. 2, it can be more conveniently provided adjacent to the driver's seat 9 as shown in Fig. 5.

Referring to Fig. 5, the control board 15 is mounted on the upper surface of a control box 30 which accommodates the electronic controller therein. Fixedly mounted on the body 1 are a pair of guide rails 31, 31 on which a bottom frame structure 32 of the seat 9 is slidably mounted. The

seat 9 comprises a seat cushion 33, an inverted U-shaped support rod 34, both lower ends of which are fixedly secured to the bottom frame structure 33, and a seat back 35 mounted to the support rod 34 through a bracket 36. C-shaped frame 37 is secured to the lower sections of the support rod 34 by means of U-shaped bolts. As is best shown in Fig. 6, the C-frame 37 has formed therein aligned holes 38 and 39 and a boss 40 welded to the frame 37. The boss 40 has a hole 41 formed therein. Although in Fig. 6 the control box 30 is detached from a bracket 42, it is bolted to the bracket 42 when assembled as shown in Fig. 5. The bracket 42 has formed therein aligned holes 43 and 44 through which a bolt 45 is inserted after aligning these holes with the holes 38 and 39 of the C-frame 37. The inserted bolt 45 can be tightened up by turning a nut 46 with suitable washers 47, 48 and 49 inserted therebetween. The bracket 42 has also formed therein a plurality of holes 50, all of which are positioned on a quarter circle having a radius R from the center of the hole 43.

Since the hole 41 of the boss 40 is separated from the center of the hole 38 the same distance R, the bracket 42 can be secured to the C-frame 37 with varying angles by inserting a pin 51 into any one of the holes 50 selected and the hole 41 formed in the boss 40.

Therefore the operator can adjust the mounting angle of the control box 30 with respect to the C-frame 37 to obtain the best suited position of the control board 15.

Referring to Figs. 7 to 10, a fork height sensor mechanism will be explained. The mast 4 comprises a pair of outer rails 55, 55′ and a pair of inner rails 56, 56′. As best shown in Fig. 8, a fork height sensor 57 is secured to a stay 58 interconnecting the inner rails 56, 56′ by bolts 59 through a bracket 60. The fork height sensor 57 may, for example, comprises a photo-electric switch having a U-shaped beam emitting portion 61 formed at the leading end thereof. A shaft 62 is secured to a plate 63 which in turn is secured to the stay 58. A roller 64 is rotatably mounted on the shaft 62 and a circular slit plate 65 is bolted to a side face of the roller 64 in such a manner that the circular slit plate 65 passes in and through the U-shaped beam emitting portion 61 and therefore intermittently blocks the beam as the roller 64 rotates. Each slit space must be made same throughout the entire circumference. A snap ring 66 prevents the roller 64 from being slipped off from the shaft 62.

Rod ends of a pair of lift cylinders 6, 6 are bolted to the stay 58. A chain 68 is wound around the roller 64 and one end of the chain 68 is connected by a bolt 69 to a stopper plate 70 which in turn is fixedly secured to a stay 71 interconnecting the outer rails 55, 55′.

The other end of the chain 68 is connected to a stopper portion (not shown) of the finger board 7. As the lift cylinders 6 extend or contract, the roller 64 rotates on the shaft 62 due to the frictional force between the roller 64 and the chain 68. Since the circular slit plate 65 is bolted to the roller 64, the former rotates together with the latter. As a result, the beam being continuously emitted from the beam emitting portion 61 is intermittently blocked by the circular slit plate 65 thereby producing ON/OFF pulse signals. These ON/OFF pulse signals are transmitted to the electronic controller and the height of the fork is detected by the number of pulses.

Referring to Fig. 10, a base height switch 72 is mounted on a bracket 73 which in turn is bolted to a lower stay 74 interconnecting the outer rails 55 and 55′. A roller section 75 of the base height switch 72 is adapted to be pushed on and off by a cam plate 76 secured to the inner rail 56′. As the base height switch 72 is pushed on, a preselected base height h_0 is displayed on the display panel 23.

Referring now to Fig. 11, mounting arrangements of a tilt position sensor mechanism will be explained. The tilt cylinder 5 has one end thereof pivotally connected by a pin 78 to a bracket 79 secured to the body 1 and other end thereof is pivotally connected by a pin 80 to the outer rail 55. Secured upright to the body 1 is a mounting plate 81 to which a limit switch 82 for detecting the upright posture of the mast 4 and another limit switch 83 for detecting a backwardly tilted posture of the mast 4 are mounted through brackets (not shown). An arc shaped cam plate 84 having its arc center at the pin 78 is secured to a barrel 85 of the tilt cylinder 5. The arc shaped cam plate 84 has formed therein a notch 86 and an upper right corner thereof is cut-off as shown so as to prevent the roller 88 from being pushed in by the cam plate 84 when the mast 4 is not fully tilted backwardly.

The limit switch 82 is mounted on the plate 81 in such a manner that the roller 87 thereof is adapted to be accommodated in the notch 86 and switched off when the mast 4 stands upright relative to the ground with no loads being imposed on the fork 8 while the limit switch 83 is mounted to the plate 81 in such a manner that the roller 88 thereof is adapted to be pushed in and therefore the limit switch 83 is switched on when the mast 4 is backwardly tilted to a preselected tilt angle.

Referring then to Fig. 12 showing diagrammatically an overall control circuit of the present invention, reference numeral 90 denotes an actuator for operating a lift valve 91 in response to an output signal from the electronic controller generally designated by reference numeral 100. The lift valve 91 when operated allows to supply fluid under pressure from a pump 92 to the lift cylinders 6 (only one is shown) thereby operating the same. Another actuator 93 is adapted to operate tilt valve 94 in response to a signal from the electronic controller 100. The tilt valve 94 when operated allows to supply fluid under pressure from the pump 92 to the tilt cylinder 5 thereby operating the same.

The operation of the present invention will now be described in detail mainly with reference to Fig.

13 showing the electronic controller 100 in block diagrams.

When an engine key switch is turned on for starting the engine, the display panel 23 of the control board displays (0 0.00). When the switch 17 for raising the fork 8 is pushed on, a clutch 123 of the lift actuator 90 is engaged and voltage applied on a motor 124 is gradually increased by a voltage controller 125. As a consequence, the motor starts to rotate slowly before it picks up its top speed thereby opening the lift vale 91 gradually which allows pressurized fluid supplied to the lift cylinders 6 to increase gradually.

Therefore the fork 8 is started to be raised gradually. During the upwards movement of the fork, the fork height sensor 57 detects the rotation of the circular slit plate 65 and generates ON/OFF pulse signals. These pulse signals are counted by a fork height counter 104 and current results of which are shown on the display panel 23 in digital fashion. While current fork height is continuously detected by the fork height sensor 57 and displayed on the display panel 23, in order to avoid detected fork height errors which may be caused by the slip between the roller 64 and the chain 68, the base height switch 72 is provided as shown in Fig. 10 in such a manner that when the cam plate 76 pushes the base height switch 72, the fork height is adjusted to a preselected base height, for example, 40 cm from the ground. Therefore whenever the base height switch 72 is pushed on by the up and down movements of the fork 8, current fork height being displayed on the display panel 23 is instantaneously corrected thereby. When the switch 17 for raising the fork is switched off after raising the fork 8 to a desired height, voltage applied on the motor 124 is not cut-off at once but is gradually decreased by the action of the voltage controller 125.

Therefore the lift valve 91 is gradually closed or moved toward the neutral position. And when a spool position sensor 121 detects the neutral position of the lift valve 91, the clutch 123 is disengaged and the fork 8 stops and is held there.

The automatic fork raising or lowering control according to the present invention will be described hereinbelow.

When it is required to raise the fork 8 to a preselected height repeatedly, the height can be memorized in a height memory 106. For example if the fork 8 is raised to a 90 cm by the manual operation set forth above and the operator wants to memorize that height in a fork height memory 106, the operator is required to push the storing switch 22 first and then any address switch among the address switch group 16.

If he pushes the address switch (1), the height memory 106 not only memorizes fork height 90 cm but also the address switch (1) pressed and the display panel 23 displays those data as (1 0.90).

Similarly if the operator wants to store a new fork height level such as 123 cm after the fork 8 is raised there by the manual operation, he pushes the switch 22 first and then address switch (2) among the address switch group 16. As a result, those data are stored in the height memory 106 and the display panel 23 displays those data as (2 1.23).

In this way the height memory can store several different fork heights and if the control board shown in Fig. 3 or Fig. 4 is used, nine different fork heights can be stored because those control boards include nine address switches, respectively. It is to be appreciated that the particular heights which are stored and read out from the memory and are used to control the movement of the fork need not be fixed but can be varied to suit the particular circumstances involved.

To effect the automatic fork raising or lowering control, one of the address switches 16 in the control board 15 is pushed. For example if the operator pushes button switch (2), the address number and address fork height are displayed on the display panel 23 as (2 1.23). Although the address fork height is shown as an independent block 107 from the height memory 106 in Fig. 13, the address fork height 107 indeed corresponds to one of the stored fork heights in the height memory 106. Therefore only for explanational convenience, the address fork height 107 is shown as independent block. When the push button switch 19 is depressed, a comparator 108 compare signals from the fork height counter 104 with a signal from the address fork height 107 and generate a signal therefrom after judging whether the current fork height is above or below the addressed fork height. If the current fork height is below the addressed fork height, the comparator 108 sends out a signal to rotate the motor 124 in a direction to raise the fork 8 as well as to engage the clutch 123. To prevent the fork 8 from being suddenly raised and minimize the shock occuring thereby, voltage applied on the motor 124 is gradually increased to a constant voltage by controlling duty ratio by means of the voltage controller 125.

When the fork 8 passes through a preset height which is about 5 to 50 cm below the level of the addressed fork height in the case of fork raising operation, a brake speed command 127 sends out brake frequency signals to a frequency comparator 111. At the same time a brake command 109 is actuated to detect current fork speed by counting ON/OFF pulses within a given time period and sends out signals to an arithmetic unit 110 where pulse signals are converted into frequency signals before being fed into the frequency comparator 111. The frequency comparator 111 compares both frequency signals from the arithmetic unit 110 and the brake speed command 127 and sends out a signal to the voltage controller 125 which is actuated thereby.

Therefore voltage applied on the motor 124 is gradually decreased thereby decreasing the fork speed.

And when the fork 8 is raised to the addressed fork height, the clutch 123 is disengaged and the fork 8 stops there without any shock.

Most tilting operation will be described hereinbelow. When the operator wants to move the mast 4 from a tilt-back position to the upright position, the push button switch 20 for tilting the mast 4 forwardly will be depressed. When the switch 20 is depressed a clutch 119 of the tilt actuator 93 is engaged and voltage applied on a motor 120 will be gradually increased by means of a voltage controller 126 thereby gradually increasing rotational speed of the motor 120. As a result, the tilt valve 94 is gradually opened to supply pressurized fluid to the tilt cylinder 5 thereby uprighting the mast 4 or tilting it forwardly from the tilt-back position. When the notch 86 of the cam plate 84 engages the roller 87 of the upright sensor or limit switch 82, the limit switch 82 is turned off and generates a signal. A comparator 115 compares the signal from the upright sensor 82 with that from the control board 15 and generates a signal to disengage the clutch 119 and bring the motor 120 to a halt. Accordingly, the mast 4 is moved to the upright position and held there. The tilting back operation of the mast 4 is similar to the tilting forward operation described above, therefore detailed descriptions thereof are omitted here.

The control board 15 has the high and low speeds change-over switch 26 as described hereinabove. When the switch 26 is changed over to low speed, a signal indicating a preset valve opening ratio from a low speed command 129 is fed into comparators 128 and 130. The comparators 128 and 130 compare the signal from the low speed command 129 with those from the spool position sensors 117 and 121, respectively, and when these signals correspond, the motor 120 and 124 are stopped but the clutches 119 and 123 are being kept engaged. Therefore the lift and tilt valves 91 and 94 are kept balanced at a preset valve opening rate. Accordingly, fork and mast moving speed can be controlled to a preset low speed. It is to be noted that the valve opening rate for low speed operation can be adjusted manually.

An automatic normal running posture operation will be described below. When the switch 25 for automatically bring the fork-lift truck to a normal running posture is depressed, the motor 124 is rotated to move the fork 8 to a preselected running level which is stored in the height memory 106 and also simultaneously or sequentially the motor 120 is rotated in a direction to tilt back the mast 4. When the tilt sensor 83 detects a predetermined tilt-back position, the clutch 119 is disengaged and the tilt valve 119 is brought back to the neutral position to stop the tilt back movement. Accordingly, the mast 4 and fork 8 are automatically brought to the normal running postures.

It should be noted that among various operational variations, the manual operation has the first priority followed by the automatic running posture operation with the least priority being placed on the automatic fork raising and lowering operation. This means that when the automatic fork raising and lowering operation is being carried out, the operator can cut in to effect the manual operation overriding the automatic operation.

CLAIMS

1. A control system for a masted lift truck comprising a computer for controlling mechanism for establishing the height of the lift and the tilt of the mast, the computer having a program for adjusting the said height and tilt operable on data recovered from a store.

2. A system according to claim 1 including a height detector, a base height indicator and a comparator therefor.

3. A system according to claim 1 or claim 2 including a voltage controller for reducing the speed of movement as a desired height or tilt is approached.

4. A system according to any preceding claim including a height display.

5. A system according to any preceding claim including a control board having various push button switches for adjusting the height and tilt.

6. A system according to any preceding claim in which the control board is mounted on a driver's seat arm.

7. A system according to claim 5 or claim 6 in which the control board is mounted on a dash board.

8. A system according to any of claims 2 to 7 in which the height detector comprises a circular slit plate rotatable with the up and down movement of the lift adapted to interrupt the passage of light to a photo-sensitive switch.

9. A system according to any preceding claim including a tilt sensor comprising a cam plate mounted on a tilt cylinder and adapted to operate limit switches.

10. A system according to any preceding claim including means for high and low speed range operation.

11. A system according to any preceding claim including means for automatically bringing the mast to normal running height and tilt.

12. A control system for a masted lift truck as herein described with reference to the drawings.

13. A masted lift truck having a control system according to any preceding claim.

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